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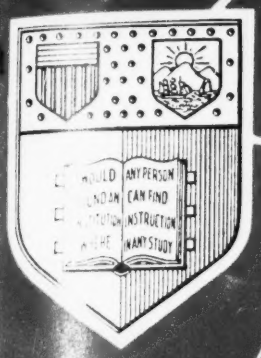

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This Month's Contributors

Professor Fred H. Rhodes, better known as "Dusty" on the engineering campus, is the energetic director of Cornell's Chemical Engineering School. Having published "Patent Law for Chemists, Engineers, and Executives" (McGraw-Hill, 1931) and a holder of several patents himself, he writes with authority on "Public Use as a Bar to Patentability."

In 1910 Wabash College awarded him the Bachelor of Arts degree. Being attracted by Cornell's chemistry department, he came here and took advanced work which led to the Ph.D. in 1914. While taking his graduate work, grad student Rhodes helped take care of his expenses by instructing the underclassmen in his department, maintaining the rank of assistant. His teaching experience during these years led to appointment as instructor of chemistry at the University of Montana (1914-1915) followed by two years of instructorship at Cornell.

The war years of 1917-1920 found Prof. Rhodes in the employ of Barrett Co., manufacturers of coal tar products, in the capacity of director of research. In 1920 he came back to Cornell for the third and final time. Entering as Professor of Industrial Chemistry, he recently became director of the School of Chemical Engineering.

Carl A. Gould, '07 C.E., author of "Engineering in National Forests," is Assistant Regional Engineer of the U. S. Forest Service at Denver, Colorado. A man of vast experience in his field, he has watched the growth of the U. S. Forest Service from humble beginnings to its present size and importance.

Although he has not returned to his alma mater since graduation, he is very active in alumni work and serves as chairman of the engineering scholarship committee for his region.

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For **MARCH** 1940

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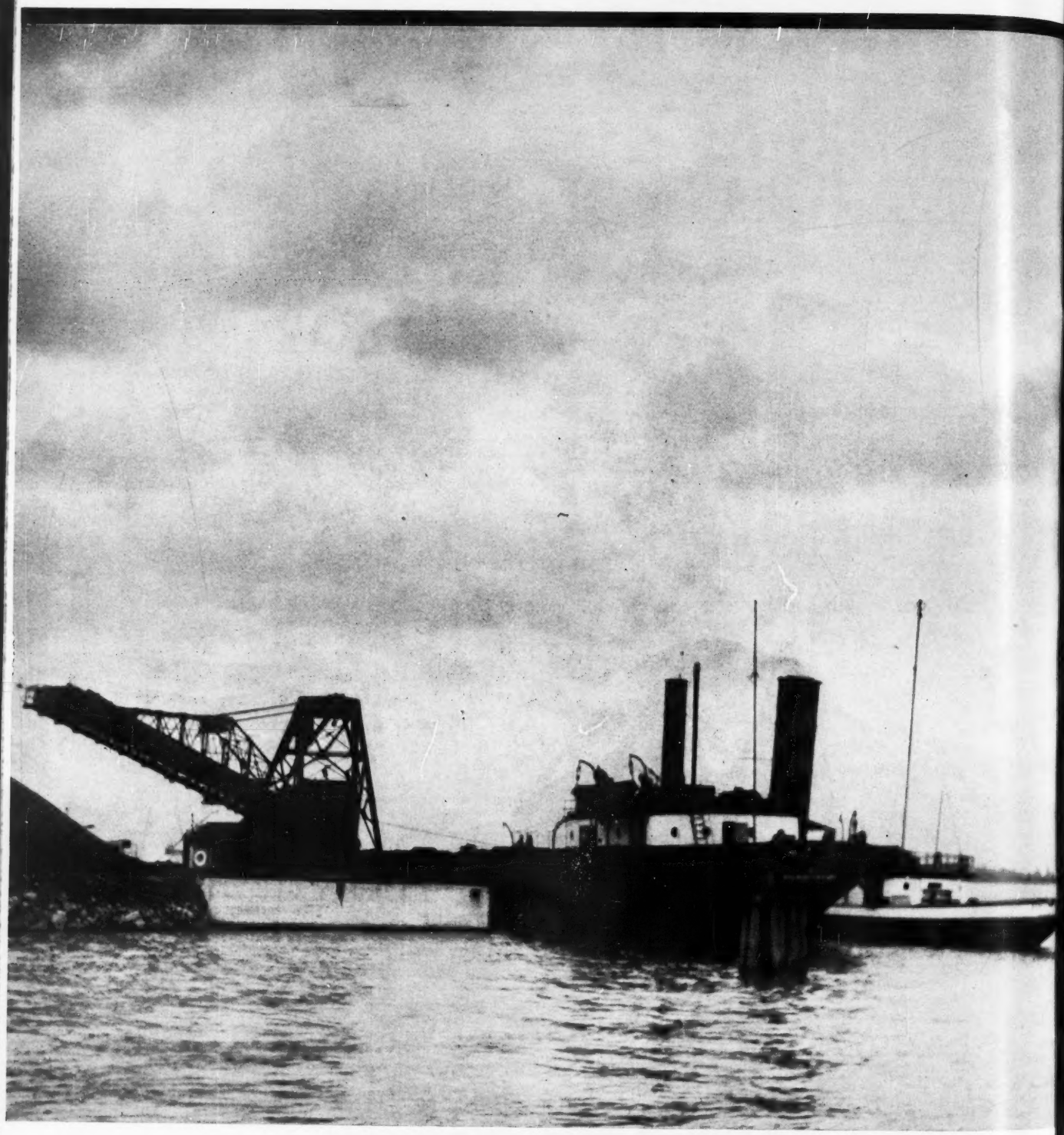


LOADING ORE ON THE GREAT LAKES

PUBLIC USE AS A BAR TO PATENTABILITY

A Few Interesting Cases In One Branch of Patent Law

By PROFESSOR F. H. RHODES

Director, School of Chemical Engineering

The present statutes specify that no United States patent may be issued for an invention that has been on sale or in public use for more than a year before the date of application for the patent.

The interpretation of the phrase "in public use" is usually clear. There are, however, circumstances under which a reasonable doubt arises as to whether or not the use of an invention is such as properly to constitute "public use" in the strict definition of the term.

An invention is certainly in public use when it is operated, for purposes of trade and profit, openly and under conditions that permit observation by the general public. This is true even when such open operation is by the inventor only. For example, if an inventor of a new process were to operate that process in his own plant under such conditions that the operation could be observed by persons under no special obligation of secrecy, the invention would be in "public use." In at least one case[1] the court has held that it is not necessary to prove that members of the general public did actually observe the operation of the invention, and that public use may be established if it can be shown that they *might* have observed it.

The courts have also held that the use of the invention by a member of the general public—that is, by a person other than the inventor or his confidential employees—constitutes public use, even when such does not permit the observation of the invention or of its mode of operation. For example, in the case of Hall and McNeal[2] the invention involved was a bolt which was built into the door of a safe. Safes provided with the new bolt were made, sold, and used by the purchasers. The court held that this constituted public use, despite the fact that in the finished safe the new bolt was so enclosed that its mode of operation was not apparent.

Another famous case in which this same issue was involved was that of Egbert vs. Lippman.[3] The inventor in this case had learned that the corset stays then available were lacking in elasticity or resiliency or whatever necessary physical properties such articles should possess, and proceeded to invent a new type of stay which would more nearly meet the ideal specifications. Stays of the new design were incorporated in a manufactured article of the type of which they are a necessary part. This article was then given to a friend (a lady friend) who used it for the purpose for which it was designed. The court held that this constituted "public use," despite the fact that the invention was not used by the general public or under conditions that permitted observation by the members of the general public.

We may, therefore, define public use as the use of the invention, as a completed device, for the purpose for which it is intended by any person other than the inventor or his confidential employees, or by the inventor himself or his employees under conditions which permit observation by others.

The statutes do not specifically state that the secret use of the invention by the inventor is a bar to patentability. There is at least one decision, however, that indicates that such secret operation, if continued for

a long time, may result in forfeiture of the right to obtain a patent. This decision was rendered in the case of the Macbeth-Evans Glass Co. vs. the General Electric Co.[4] In this particular instance the secret operation had continued for about nine years before the application for a patent was filed. We have no authoritative statement as to just how long such secret operation must continue before the inventor loses his right to a valid patent.

The law appears to be that the inventor who elects to operate his invention secretly for a long time is free to do so, but if he does so elect, he cannot later seek and obtain that legal monopoly under the patent laws that he has previously disdained.

On the other hand, under certain conditions the inventor may operate his invention publicly and may even permit others to so operate it without prejudice to his right to secure a valid patent later. This is true when the use of the device is such that it may properly be considered *experimental use.*

Certain inventions are such that they can be tested adequately only by being used under actual conditions of service. For example, the true value of a new textile fibre could be determined only by spinning it into yarn, weaving the yarn into cloth, and subjecting the cloth to exposure, wear, and washing. If such use of the fibre were primarily for the purpose of testing it, to establish its relative value with reference to other available fibres, and to discover defects that might be remedied by further research, it would be classed as experimental use and not public use, and would not act as a bar to future patentability. This would be true even if the experimental use were by persons other than the inventor or his employees and even if it were open to inspection by members of the general public.

A case in point is that of City of Elizabeth vs. American Nicholson Paving Co.[5] The invention here involved was a new kind of paving block. The inventor had, at his own expense, paved a section of public road with his new blocks and, for more than two years, had observed closely its durability under traffic. He then applied for, and was granted, a patent. The validity of this patent was later attacked on the basis of the argument that the invention had been in public use for more than the stated limit of time before the date of application. The court ruled that the previous use, although it was by the public and open to public observation, was not truly "public use" but was "experimental use."

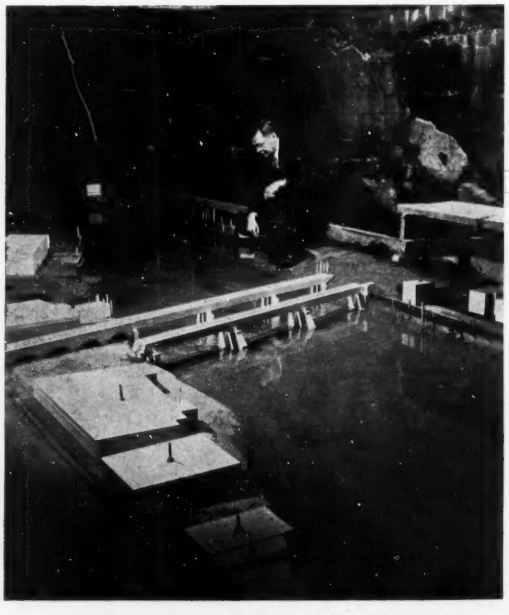
That a profit accrues during the operation of an invention for purposes of testing does not, of itself, prove that such operation is "public" rather than "experimental." In the case of American Caramel Co. vs. Thomas Mills and Bro.[6] a newly invented candy-cutter was tested by being used to cut caramels. The caramels thus cut were sold. The court held that such sale of the product did not necessarily indicate that the device was not in experimental use.

The essential distinction between experimental use and public use is that of purpose. A device is in experimental use when it is used, even openly, for the principal purpose of disclosing defects and pointing the way to possible improvement; use primarily for production and profit is public use unless kept closely secret. In border-line cases the courts may rule that use was "experimental" rather than "public" when the operation was under unusually close supervision, and when an unusually detailed record of the performance was kept.

That the experience gained during the early operation of an invention leads to improvement is not, of itself, proof that such operation is experimental. Many devices are initially so imperfect that their use under even routine conditions and casual inspection will reveal defects and suggest improvements. Failure of the initial operation to disclose faults and to suggest modification does not prove that the use was not experimental; some new inventions are so nearly perfect that even long and careful testing discloses no serious defects.

The inventor of a new device may forfeit his right to a patent if he fails to file application within a year of the date on which his invention was first put into public use; truly experimental use is no bar to patentability even if it continues for a long time.

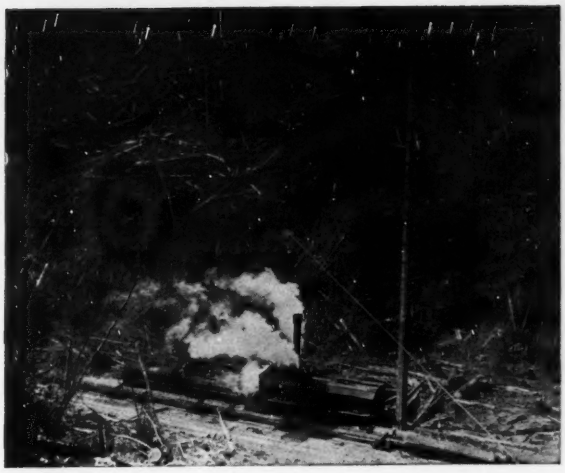
1. Perkins vs. Nassau Card Co., Fed. Rep. *2,* 451.
2. Hall and McNeale, U. S. *107,* 90.
3. Egbert vs. Lippman, U. S. *104,* 333.
4. Macbeth-Evans Glass Co. vs. General Electric Co., Fed. Rep. *246,* 695.
5. City of Elizabeth vs. American Nicholson Paving Co., U. S. *97,* 126.
6. American Caramel Co. vs. Thomas Mills and Bro., Fed. Rep. *149,* 743.



Dean Hollister Inspecting Flood Control Model

Engineering In The National Forests

By **CARL A. GOULD, C.E. '07**
United States Forest Service



When forestry is mentioned, most people think of trees and more trees; they seldom give thought to the activities which are essentially a part of an organization established to administer and protect the National Forests. When one sees a forest in the stage of growth development, it is not surprising that the average individual should consider it as a great number of trees growing, perhaps by chance, to be cut as needed for wooden construction, paper pulp, and the various uses and by-products which have been developed through laboratory research.

The natural resources of the large forested areas, i.e. water, wood, and forage, cannot be guarded and efficiently controlled without building transportation systems to the interiors and providing therein adequate facilities for men to live and equipment to operate. An engineer, therefore, has a very definite place in forestry work, for although many of the engineering projects are comparatively small, there are a great number of them, in which sound engineering principles are just as important as in large projects.

A greater portion of the National Forests, particularly in the western United States, are in high country, which is by nature well adapted to tree growth, the retention of snow which provides a summer supply of water, and forage available for mid-summer stock grazing.

The National Forests of the United States cover approximately 175,000,000 acres and are geographically separated into ten Regions with a Regional Forester in charge. There are 158 National Forests averaging over a million acres, each of which is under the direct control of a supervisor, who in turn has a sufficient number of Forest Rangers to carry out the established policies.

To regulate and utilize the resources of these areas, boundaries must be established, roads and road structures built, horse trails constructed, and man-made erosion reduced. Communication systems must be established, lookout towers placed on commanding ridges and peaks for the detection of fires, buildings erected for forest service personnel and recreational use, and sanitary sewer and waterworks systems provided. Water resources must be developed and maintained by the construction of dams, reservoirs, and revetments, and bank protection structures and equipment of all kinds must be kept in good repair. The maintenance problem is not small when considered in the aggregate; all of the undertakings require engineering knowledge and counsel.

Surveying, mapping, and designing are important functions required in varying degrees for all projects undertaken. In recent years aerial methods have provided a means for doing accurate surveying and mapping work in much larger quantity, at less cost, than the former elaborate field party system.

Aerial surveys are made principally for location of drainage systems, roads, buildings, and culture, and provide an accurate general map showing the correct positions of such features. All aerial photographs contain points whose latitude and longitude have been established by primary triangulation survey networks. The photographs show all the primary stations within the survey project, and every photograph has points which have been established and identified through fourth-order control methods of triangulation under the supervision of the engineering division.

The primary triangulation net is established by the U. S. Coast and Geodetic Survey or the U. S. Geological Survey, while the Forest Service does all the necessary fourth-order control work.

An area is so photographed that all pictures have an overlap of 60% in line of flight and not less than 15% for adjacent flights. By means of the stereoscope the third dimension of the terrain is produced, thus making possible a thorough study of topography.

The processing of film and reproduction of photographs is a very precise detail and requires a knowledge of photographic chemistry. This work as well as all other necessary steps from the flying and photo-

graphing of an area down to the compilation of maps by aerial methods requires the services of well trained engineers and draftsmen.

Surveys for all improvement and development work have to be made by field parties using ground methods, since the detail required is not possible by aerial methods.

Equipment for roads, dams, and other improvements comprise practically every type used in the construction and maintenance field; the sizes vary to meet the needs of the project undertaken.

There are mechanical engineers and mechanics who have designed and constructed in Forest Service shops equipment units which are particularly adapted to the needs of the forest. Some of these units have become standard with the construction industry. One outstanding example is the trail-builder, which was originated in a Forest Service shop and piloted through the experimental stage by Forest Service men.

The U. S. Patent Office currently issues patents to Forest Service Personnel for new and useful processes in the utilization of wood and its by-products; the Forest Products Laboratory at Madison, Wisconsin is constantly working with wood problems, and is considered one of the finest laboratories in the world in this line of endeavor. Patents have also been issued for new designs in engineering equipment for both field and office. All patents, of which the writer has knowledge, have been donated to the free use of the people of the United States.

Thus far we have drawn into the picture of forestry, engineers, architects, surveyors, topographers, photographers, chemists, draftsmen, inspectors, and engineering aides. The engineering work covers the following classifications: civil, structural, highway, hydraulic, mechanical, electrical, hydro-electric, sanitary, and construction.

The location, design, and construction of roads are all handled by men, who, through technical training and professional experience, have become familiar with forest needs. Roads must be built for hauling timber to the mills and on to the market, for recreational routes to camp grounds and fishing points, and for travel by the men responsible for the economical administration of the areas involved. Connecting roads between towns within and outside the forests have to be built for general cross-country use. The transportation system for the National Forests, as now planned, includes 24,175 miles of forest highways, 113,396 miles of forest development roads, and 152,840 miles of horse and foot trails. In 1938 approximately 46 percent of the highway and road mileage had been completed and 78 percent of the trail system.

Artificial Lake For Recreation Impounded By Sibley Dam.

The width, alignment, and grade of the forest roads depends on the class of service to be rendered. The width varies from 10 feet for a one-way, unsurfaced, with turn-outs, to 22 feet width for a two-way surfaced road. The volume of traffic and the importance of the activity served determines the standard. Bridges are constructed for a 15 ton safe load, using the standard factors of safety. Transportation studies are conducted to show the trends and future needs of traffic. Traffic counts of present travel are made, timber and grazing resources evaluated, recreation areas assigned values, and economic alignment of future construction determined.

Some landing fields have been constructed in back country forested areas, where road construction is impossible, to permit the fighting of fires with the aid of airplanes. The planes are used to transport men and supplies, and to scout the burning areas to secure information as to the extent of the fire and thus enable efficient fire fighting plans to be carried out.

To many people, trails are foot paths only, while in the Forest they serve many purposes. The forest must be patrolled, sheep and cattle driven back into the interior for grazing, and primitive and wild life areas made accessible.

The development of water resources, of recent years referred to as "Upstream Engineering," is an activity, the importance of which is recognized by the Forest Service, and is being carried on as rapidly as funds will permit. Water conservation for irrigation, domestic use, flood control, stock watering, fish culture, and recreational use are among the purposes for which water resources development is carried on. Water power development within the boundaries of the National Forests is an administrative responsibility of the Engineering Division acting as a representative of the Federal Power Commission.

Lookout towers vary in height from 10 feet on high, exposed points to 130 feet where visibility is poor or practically nil on the natural terrain. The high towers are pre-fabricated of either wood or steel and erected by connecting bolts, while many of the towers up to 50 feet height are designed and constructed of native round material. With the exact location of

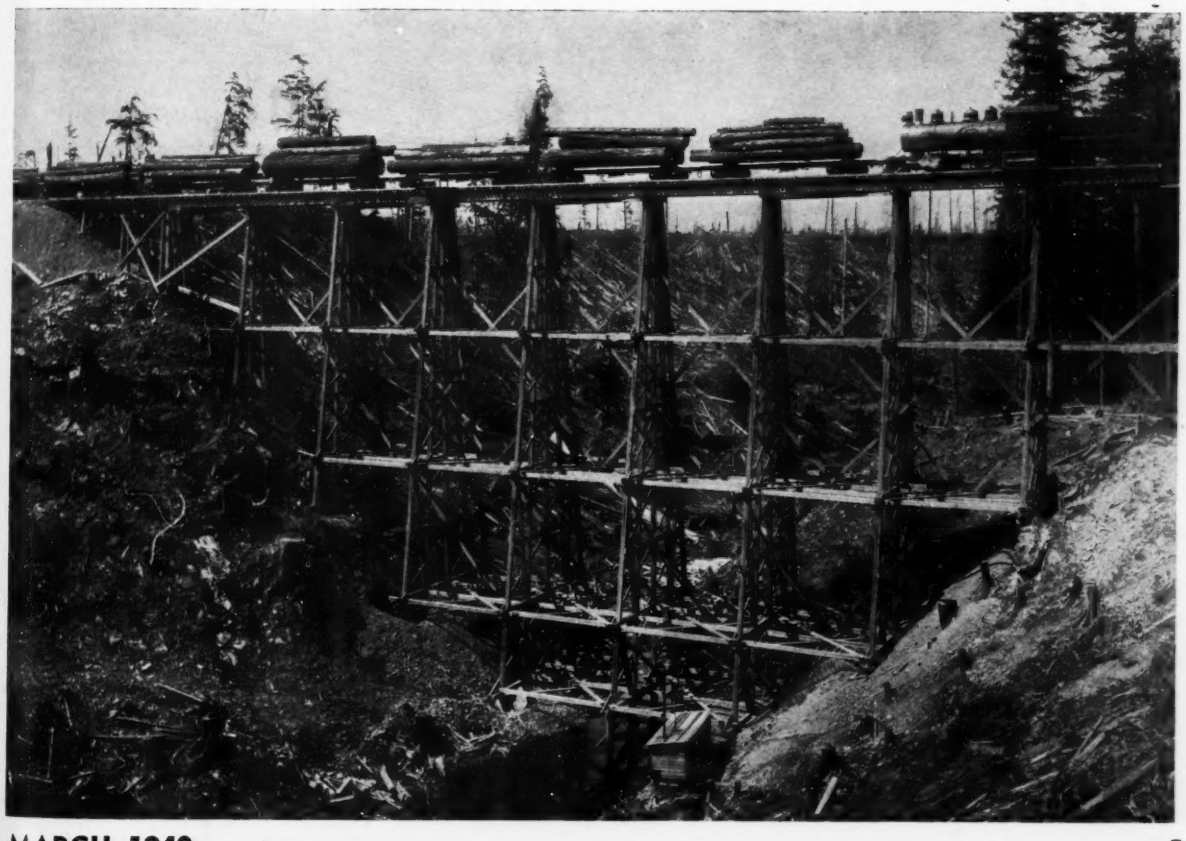
lookout towers determined by triangulation, it is quite a simple problem for three lookout towers to spot accurately the start of a forest fire. The bearing from each lookout to the first rising smoke is telephoned to headquarters, where the lines are projected on a base map of the forest; the three-point intersection shows th exact spot where the fire is just starting. By this means is secured quick action in getting men and fire-fighting equipment on the fire line to put out the blaze before serious damage results.

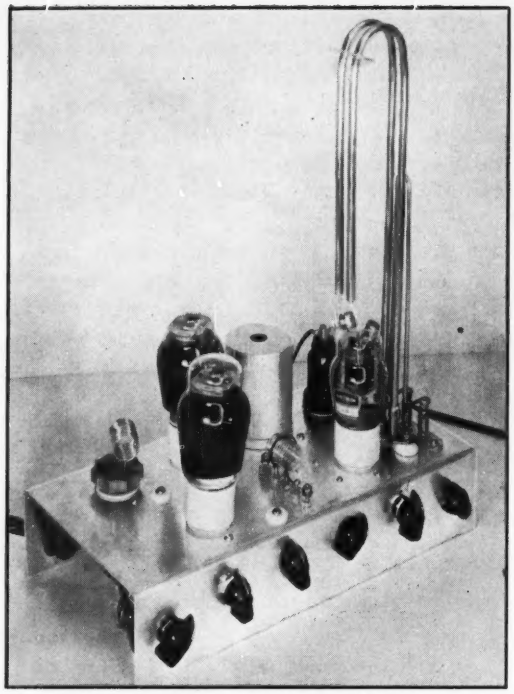
The communication systems connect Ranger districts and other key points; at the present time telephone and radio are the only instruments used. In the earlier days of the Forest Service a great deal of grounded telephone line was built using existing trees for poles. Wind, rain, ice, and snow made these lines a heavy financial load from the maintenance point of view, since short circuits could be easily effected by storms. At the present time metallic circuits on wood poles are standard; grounded lines are only used where extremely temporary service is required. The high country in the Rocky Mountain region brings forth ingenuity in the construction and maintenance problems involved. Galvanized iron, copper-covered and also solid copper wires are used, depending on the service to be rendered, the length of the line, the character of the terrain, and the amount of speech load carried. The writer has talked over a single wire, grounded line, a distance of 90 miles, throughout much of which the single wire was strung on trees. While speech level was anything but good, conversation was still possible. These old ground circuits are being replaced with metallic circuits.

Portable radio sets are not in general use, but have, in some localities, given excellent service. During fire season it is necessary to have someone on duty at headquarters constantly, during extreme fire hazard weather, to get any messages which might come in from the radio sets throughout the forest. For regular business, certain hours are set up for radio communication.

From this general description of activities in the Forest Service which depend on engineering knowledge, advice, and execution, it is apparent that men are sought with broad backgrounds of professional training and practical experience in not only engineering subjects, but those which deal with the propagation, protection, administration, and utilization of forest resources.

All engineering positions are classified by the Civil Service Commission, and a young man entering the Forest Service comes in through competitive Civil Service Examinations. The engineers start in the lower classified positions, where there is plenty of opportunity to advance for the men who not only have a thorough technical knowledge of the required engineering subjects, but also qualifications and promise in the fields of administration and public relations.





Low Power Amateur Transmitter
—Courtesy of QST

FREQUENCY MODULATION

The Newest Development In Staticless Radio

By RUTH E. DYNES, E.E. '42

Static-free reception has been a goal of the communications industry during the last quarter century. Successive technical problems succumbed to radio engineering research, but static persisted; although it could be minimized, it could not be eliminated. A system of wide-band frequency-modulation, however, has lately been developed by Major Edwin H. Armstrong, Professor of Electrical Engineering at Columbia University, which, operated on ultra-high-frequencies, reduces distortion, noise, and interference to the point where reception may be said to be perfect. What static there is cannot be detected by the human ear. This article offers a digest of technical and general literature on the subject.

History

The history of the development of a workable system of frequency-modulation has been the story of Armstrong's life since the first World War. He became interested in the possibility of reducing noise in 1914, when he was studying under Michael Pupin at Columbia. The undesirable noise in receivers is caused by amplitude variations superimposed on the wave envelope as transmitted. Receivers for amplitude-modulated radio are designed to pick up just such variations. It is not possible, therefore, to discriminate against noise, when it has the same characteristics as the desired signal (i.e., broadcast program). Armstrong began work on the theory that if the signal were modulated by some other means, and if the receiver were designed to pick up only this differently-modulated wave, remaining unresponsive to amplitude variations, reception could be accomplished which would be noise-free. The Armstrong system and other methods of phase- or frequency-modulating the carrier wave offer such a means.

Armstrong gave up work on the problem at times, inventing the superheterodyne and superregenerative circuits. He was also one of the inventors of the regenerative feed-back circuit. These important designs have brought in sufficient royalties so that Armstrong can finance his own research, a factor in the swift development of frequency-modulation since he received patents on his system in 1933. He invested somewhat under a third of a million dollars in his experimental station, W2XMN, and since then has been demonstrating frequency-modulation in operation.

Advantages

The results of intensive tests by Armstrong and national electrical concerns have shown unquestionable advantages which frequency-modulation possesses over amplitude-modulation. Values given here for the gain of frequency-modulation over amplitude-modulation are taken from experimental data; since tests are still going on, they may prove to be either conservative or over-optimistic. They indicate, nevertheless, the general advantages involved in the use of frequency-modulation.

To the broadcast listener, frequency-modulation offers reception characterized by the highest fidelity, and freedom from both static and that interference caused by the cross-modulation of one station's signal

by another operating on the same frequency. Although the human ear is sensitive to a range of 15 kilocycles in sound waves, in network broadcasting reproduction of about 5 kilocycles is the rule. Radio-frequency noise occurring in frequency-modulation increases with frequency, inversely as the ability of the ear to note it; however, the majority of the distortion is shifted above the audio frequencies.

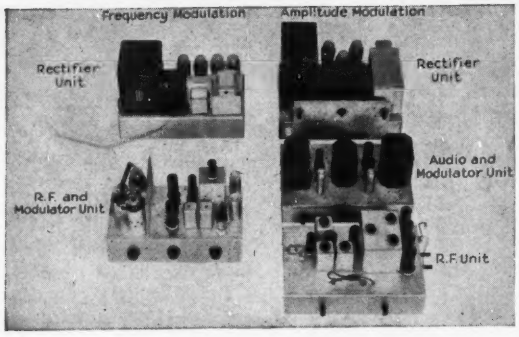
To demonstrate the freedom from interference caused by two stations operating on nearly the same frequency, an auto was driven between W2XMN at Alpine, New Jersey, ten miles north of New York City, and a frequency-modulated station constructed by General Electric, in Albany, 130 miles north of Alpine. Throughout the distance either one or the other station was heard; on the fringe of the two service areas the stations might be heard simultaneously, but a slight shift of the antenna would eliminate one signal. General Electric engineers reported that "whenever the strength of the signal was greater than twice the other, the field strength of the stronger signal would prevail 100%", while "the desired amplitude-modulated signal must be at least thirty times the undesired signal before interference is low enough for suitable broadcast reception." On these same tests, the test car was parked under a 41.5 megacycle, 50 watt antenna, and the receiver tuned to a 41.0 megacycle, 150 watt broadcast fifteen miles away. There was no interference from the nearer of the two stations.

By the use of a directive antenna, the number of stations heard at a given set may be increased. The strength of the received signal in any case is proportional to the power of the transmitter and its separation from the receiver, as with amplitude-modulation. Since frequency-modulation operates on the ultra-high-spectrum, its waves cannot take the so-called "sky path" as can long waves, that is, be reflected from the ionosphere and thus travel beyond the horizon, but are radiated outward and go completely through the ionosphere. Their range is mainly confined to the horizon; thus, increasing the height of the antenna increases the range of the transmitter. The turnstile antenna at W2XMN is 400 feet above ground and is situated on a cliff. As far as the horizon, it has been found that the field energy is inversely proportional to the square of the distance between the transmitter and receiver. Beyond the horizon, the field strength is inversely proportional to a higher power of the separation. At 42 mc, this has been calculated to be about 3.6, when no account is taken of fading. Fading occurs in frequency-modulation as in amplitude-modulation, but the use of an automatic volume control device compensates it; at no time does fidelity suffer.

The listening public has not switched to frequency-modulation in spite of these advantages. Here we run into the most important side of the frequency-modulation system—the fact that its technical aspects cannot be considered apart from the economic, a problem which has long confronted television. Listeners cannot get sufficient variety of programs at present from frequency-modulated stations. Amplitude-modulated sets cannot be simply adapted for frequency-modulation reception. Therefore, new sets must be bought. Furthermore, the western part of the country is not serviced at all by frequency-modulated radio. Only between 2000 and 5000 sets have been sold, in comparison with the 45 million receivers in the United States, although seven manufacturers are licensed to use Armstrong patents and are already offering a variety of sets.

Station-owners have shown the greatest activity since frequency-modulation was made practicable. Five stations are operating, among them W2XMN, with 40 kilowatts maximum power, and WIXOJ, with 2 kilowatts power operating on 43 mc., the latter owned by the Yankee Network, and operated at Paxton, Mass., in conjunction with a 250 watt, 133 mc. relay transmitter in Boston, 45 miles distance. The signals from WIXOJ have been regularly heard in New York City. These were the pioneer stations, with W2XCR, (ex-amateur W2AG), at Yonkers, New York. Fifteen other stations are either operating or have received construction permits. In addition, 80 applications are under consideration by the Federal Communications Commission. The National Broadcasting Com-

Frequency Modulation Receiver
—Courtesy of General Electric Review



Rear View of the Receiver on the Preceding Page.
—Courtesy of General Electric Review

pany, the Bell Telephone Laboratories, the Mutual Broadcasting Co., and Stromberg-Carlson have construction permits, General Electric and Westinghouse are operating at the present time, and the Columbia Broadcasting System and Zenith Radio have applied for permits.

Owners of the nation's 750 amplitude-modulated stations are faced by the necessity of installing completely new equipment if they wish to change systems; yet they have not a sufficiently wide listening public to expect revenue from advertisers immediately. Against these drawbacks may be listed a large number of advantages in using frequency-modulation.

In the first place, both the initial cost and running expenses are lower for a given power station. In the second place, the same service can be furnished with less power, or conversely, a larger area (within limits already mentioned) may be covered by the same power. The elimination of noise is mainly responsible for this advantage: when the ratio of signal to noise is 10 to 1 in the limiter stage of the receiver, in the speaker the ratio will be 1100 to 1; when 4 to 1, it becomes 700 to 1; when 2 to 1,it drops to 400 to 1; and finally if the signal and noise are equal, in the speaker the ratio will be 2 to 1. In addition, technicians are not required to monitor a program, preventing over-modulation from occurring from loud signals; frequency-modulation can stand over-modulation up to 300% without damage to the transmitting tubes. Economy results from the fact that although a large number of tubes are needed for frequency-modulation, they are of the receiving type operating at less than their voltage rating. Frequency-modulation can be operated with class-C amplifiers, which have a higher efficiency than class-B amplifiers used in amplitude-modulation. Furthermore, the power level is constant and equal to that of the carrier instead of varying up to a value of four times the carrier. The cost of a coast-to-coast network has been estimated to be considerably lower than that of a similar coverage using amplitude-modulation; a saving of two or three to one is commonly cited for a single station.

Manufacturers at present are not enthusiastic over the changes which frequency-modulation may bring, not because of lack of vision on their part, but rather because of their concern over their production equipment, which is designed for amplitude-modulated transmitters and receivers, and over the large sums invested in research on amplitude-modulated devices. The prospect of selling a complete new line of communications apparatus, however, is a cheerful one; in the meantime, they are prepared to sell either type. One company has a line of five transmitters: a relay with 250 watts rating, and others with 1, 3, 10 and 50 kilowatts ratings. Another is experimenting and may sell equipment later. Still another is manufacturing 1, 2, 3, 5 and 50 kilowatt transmitters.

Future Possibilities

In solving radio's major problem, Armstrong may prove to have solved television's as well—that is, the need for an economic means of sending video signals over long distances. At present, they may be transmitted through the air by means of electro-magnetic waves, having, since they are ultra short, an optical range. An alternative has been the use of the coaxial cable, which in its present form is too expensive a method for commercial exploitation. Ultra-high-frequency frequency-modulated waves can accommodate the wide television band, have a dependable range of a hundred miles, and have transmission whose fidelity is sensibly independent of atmospheric and local disturbances. General Electric reported on experiments showing that frequency-modulation reduces ghost images caused by a signal, which has taken the sky path, arriving slightly later than the same signal which took the ground path. The National Broadcasting Company has conducted tests using frequency-modulation relays for television programs and are optimistic about its possibilities. A coast-to-coast transmission of telecasts thus may finally become a reality.

The possibilities of frequency-modulation being used in the space-transmission of ordinary radio programs jeopardizes the revenue derived by telephone companies who rent cables for this purpose. Recourse to wire transmission was made by national networks because they offered a high-fidelity relay which, of course, was not affected by weather conditions; frequency-modulation permits a relay service flat from 30 to 15,000 cycles per second, that is, the audible range, within 1 decibel. Telephone companies could duplicate this only at a price above that of frequency-modulation. The Armstrong system may be of benefit in the case of aviation radio, preventing accidents in which pilots have been unable to separate airport signals from the welter of cross-talk which periods of good-reception make possible, and from static which accompanies periods of poor reception.

Theory

In order for intelligence to be transmitted by radio, the carrier wave radiated from the antenna must be periodically altered, or modulated, in order to convey two characteristics of sound: pitch, and the intensity or volume. Assume a carrier wave of the form,

$$e = E_c \sin w_c t$$

where e equals the instantaneous value of the voltage. E_c its maximum value, w_c two π times its frequency. Assume that a signal which is to be radiated is of the similar form,

$$e = E_s \sin w_s t$$

where w_s now equals 2π times the frequency of the sound. This second wave may be caused to modulate the carrier by altering its phase, its frequency, or its amplitude.

It has been the rule in commercial broadcasting to amplitude-modulate the wave: the amplitude of the carrier is varied in proportion to the intensity of the signal, or the degree of its loudness, and its frequency in proportion to the pitch of the signal. The modulated wave envelope can be given by the equation,

$$e = E_c \sin w_c t\ (1 + M \sin w_s t)$$

where M indicates the ratio between the maximum amplitude of the modulation envelope and that of the carrier. This degree of modulation may vary between zero and one in value; it is often commonly expressed as a percentage, in which case the maximum modulation would be 100. When expanded, the equation above becomes,

$$e = E_c \sin w_c t + \frac{E_c M}{2} \cos (w_c - w_s)t - \frac{E_c M}{2} \cos (w_c + w_s)t$$

In addition to the carrier there are now present two side-bands having frequencies differing from the carrier by plus or minus the signal frequency. The band width needed to reproduce a program faithfully will therefore equal twice the highest pitch of the signal.

An example: assume a 1 kc. note is modulating at 40 mc. carrier, with maximum amplitude 10v. If the modulation is 100%, the maximum amplitude of the signal will also be 10v. The side-bands generated will have frequencies of 40.001 mc. and 39.999 mc., and the wave envelope will vary in amplitude from zero to 20 v. The band will be 2 kc wide. In practice one of the side-bands can be suppressed to narrow the band width, but the energy content of the transmitted wave is similarly decreased.

In the competition between the various types of communication, each of which is expanding, commercial broadcasting has found itself with limited bands within which to operate. It is, in fact, necessary to distort deliberately both pitch and volume values in order to keep within allotted bands. It early occurred to broadcasters and inventors that if the usual band needed by a station, about 10 kc., could be reduced to say, 2 kc., it would have permitted a larger number of stations to operate. It was the belief that frequency-modulation was the solution which stimulated research originally.

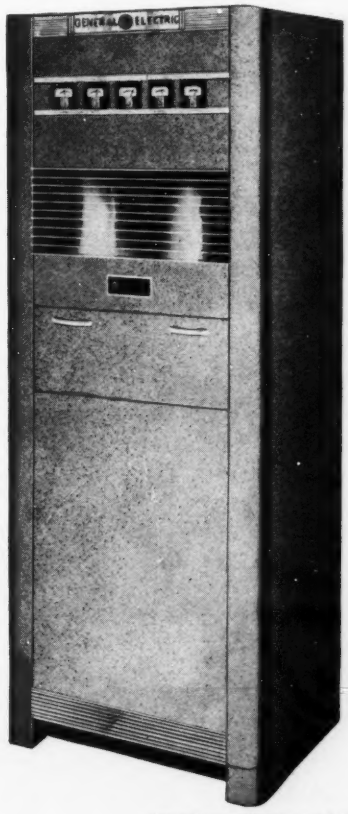
In frequency-modulation, the intensity of a signal causes the frequency of the carrier to vary, and its pitch causes the rate of change of this frequency to vary. Using our previous example, the frequency would vary between the limits of 40.150 mc. and 39.850 mc., 1000 times a second. The maximum amplitude would remain constant at 10v, the carrier level. The swing of plus or minus 75 kc. about the carrier corresponds to the maximum amplitude deviation in amplitude-modulation. At first sight, it seemed that the magnitude of this swing could be arbitrarily chosen and the band width thus made as small as desired. John R. Carson in 1922 showed that frequency-modulation was far from being thus pliable, by a mathematical analysis similar to the following:

Starting with the fundamental relation that the voltage of the wave envelope at any instant will be approximately a sinusoidal function, it may be represented by,

$$e = A \sin \phi$$

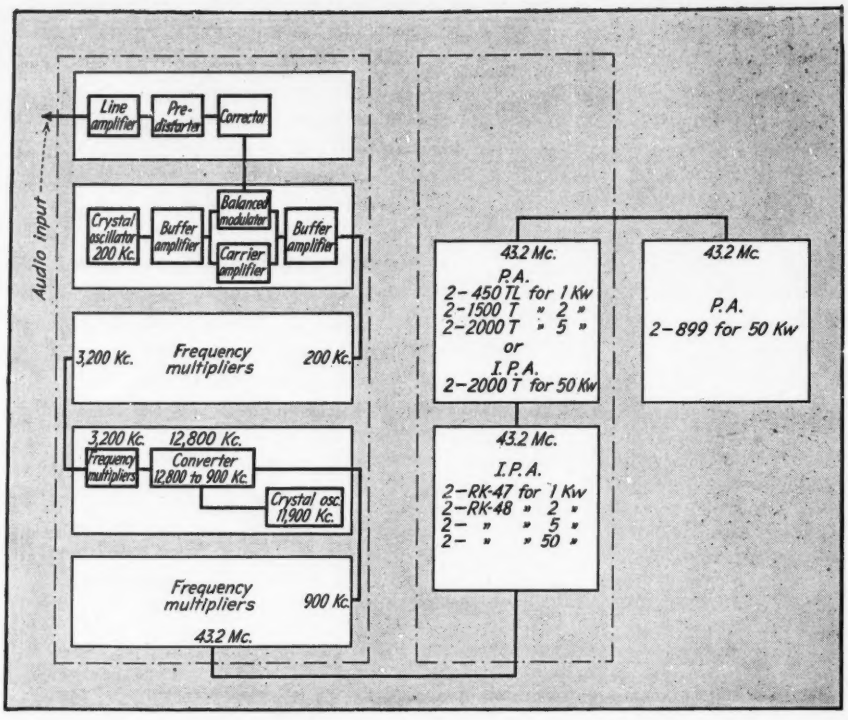
The angle ϕ is equal to the original shift of the carrier, θ plus the integral of its angular velocity times the elapsed time,

$$\phi = \theta + \int w dt$$



—Courtesy of General Electric News

Commercial Frequency Modulation Transmitter

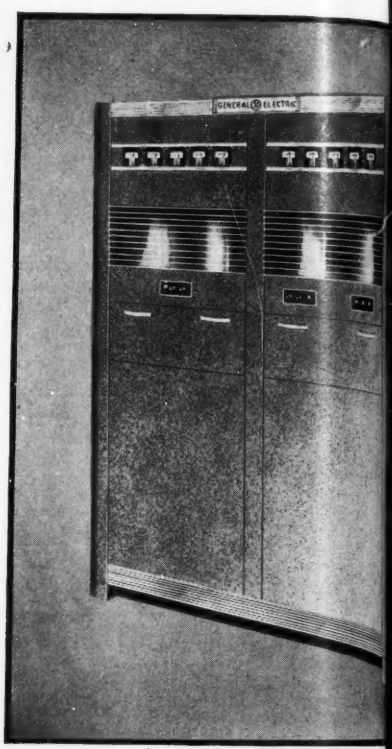


Left:

ARMSTRONG FREQUENCY MODULATION SYSTEM

Below:

LOW POWER TRANSMITTERS USED AS RELAYS



In the amplitude-modulation case, the was a constant, but in frequency modulation, it is the variable chosen to modulate the wave.

$$w = w_o\ (1 + K \cos w_s t)$$

That is, the frequency of the carrier is equal to that of the unmodulated carrier plus a modifying frequency proportional to the impressed signal. Substituting 3 into 2, and the result into 1, the final equation is given by,

$$e = A_o \sin w_o t + A_o \sin K \sin w_s t$$

The second term, by the use of Bessel's function, can be expanded into an infinite series. Thus, whereas amplitude-modulation only generates two side-bands, frequency-modulation yields an infinite number of them. The first-order bands are separated from the carrier by the pitch frequency, and the higher bands from each other by the same amount. When it was shown that the band width was infinite, it was assumed that frequency-modulation was impractical. This has not proved to be the case, but neither has the original purpose in these experiments been accomplished—the narrowing of the band width. Its advantage has been in another phase of radio: the reduction of undesired noise.

The factor which makes frequency-modulation possible is that if the phase shift is kept below 30 degrees, the side-bands above the first order become very small. The intelligence being transmitted can be represented by the first-order bands with accuracy, the band width then being, as in amplitude-modulation, twice the highest signal frequency. It is further desirable to keep the first-order side-bands predominant because the amplitudes of the higher orders are not proportional to the signal, which fact would introduce distortion. Narrow-band frequency-modulation does not reduce noise above the amplitude-modulation standard. Armstrong therefore shifted the carrier into the ultra-high spectrum where wide-bands were available.

The Armstrong System

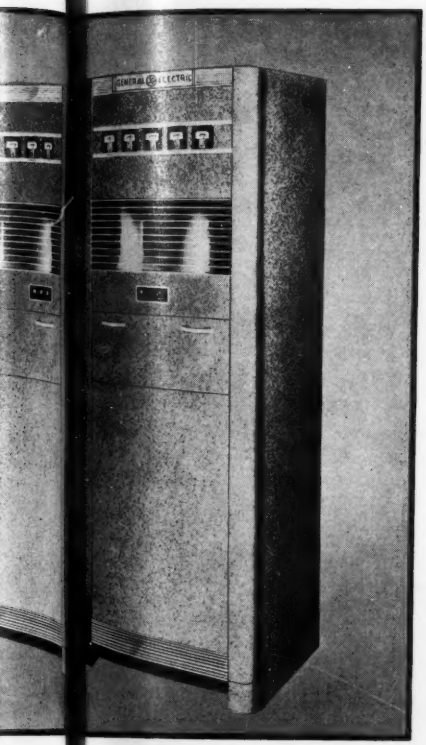
The following description of the methods used in frequency-modulation will be confined to the original Armstrong system. Modifications have already been made, but the fundamental principles may be understood from an examination of the Armstrong transmitting and receiving circuits. A later design re-

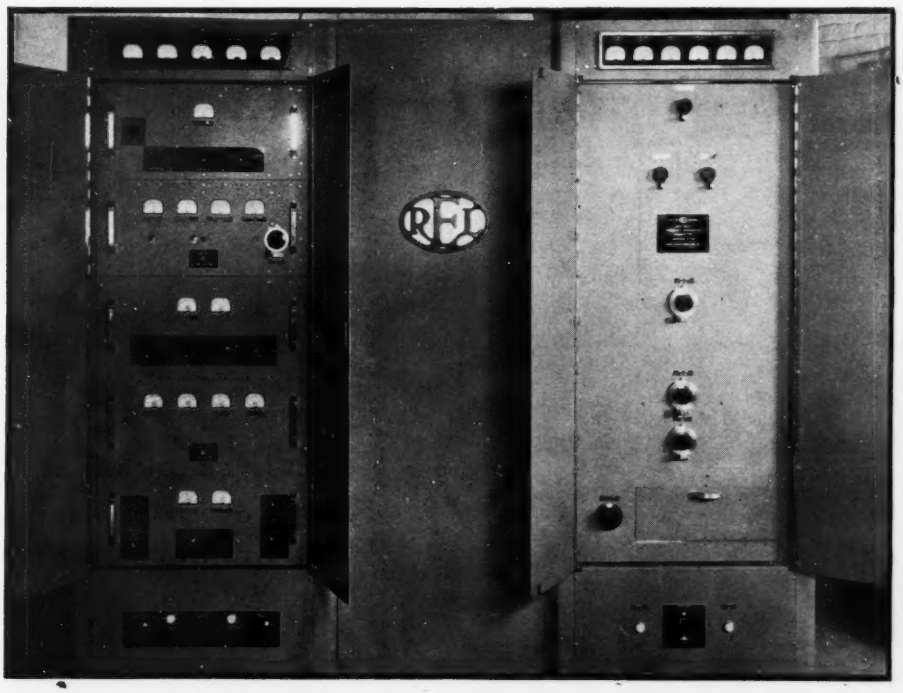
duces the number of tubes needed in the modulator.

While granting the improvement of signal-to-noise ratio of this system over amplitude-modulation, it must be kept in mind that the wide-band used and the strict linearity of the Armstrong system throughout are responsible for improvements in themselves. Amplitude modulation can achieve the finest fidelity which the ear is capable of appreciating, but noise invalidates much of this fidelity. Frequency-modulation does not inherently offer higher quality reproduction; it does offer listeners the chance to hear the full range of a set without the interference of noise.

In the transmitter, the phase of the carrier is changed in proportion to the amplitude of the signal. This change must be independent of the frequency of the signal. The audio input is first pre-amplified, then fed to a corrector network containing high resistance and capacitance, where the signal is amplified in inverse proportion to its frequency. This is necessary to meet the second requirement, that the change of phase be independent of frequency. The change in shift of the carrier at a rate corresponding to the pitch of the signal itself introduces an additional change in phase. Obviously this distortion will increase with the number of times the phase is changed per second, and therefore, at the receiver, the highest frequencies will come in more loudly than the low frequencies, since by this system, the phase shift of the carrier at any instant corresponds to the instantaneous volume of the signal.

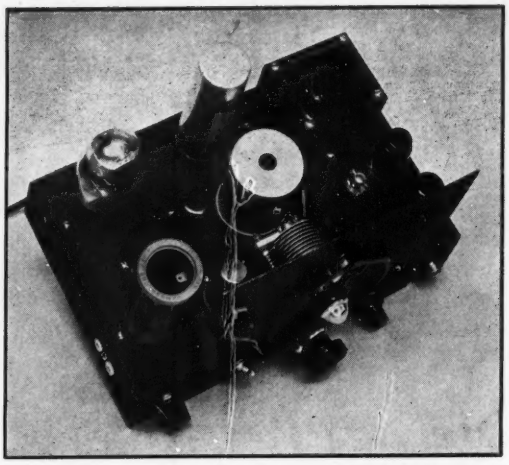
From this circuit, the signal is fed through a transformer to a balanced modulator, where it is applied to the control-grids. The tubes of the modulator are unbalanced by the modulating voltage and its plate currents are in phase with this voltage. Each of the plate currents goes through one of a pair of resonant circuits, which, being non-reactive to the original carrier-frequency, change the phase of the currents only in proportion to the amplitude of the signal voltage. The side-bands are linked to a side-band amplifier by a transformer, thus undergoing a 90 degree shift relative to the carrier. The output of the amplifier is applied across a resistance load in which is also flowing a current of, say, 200 kc. frequency, crystal-controlled, which is of constant amplitude.





Right:
TYPE OF TRANSMITTER USED BY PRESENT EXPERIMENTAL STATIONS

Cuts on this page
Courtesy of "Electronics"



Amateur Receiver For Frequency Modulation.
—Courtesy of QST

Across this load, then, where the unmodulated carrier and modulating current combine, the phase shift will be proportional to the amplitude and inversely proportional to the signal frequency.

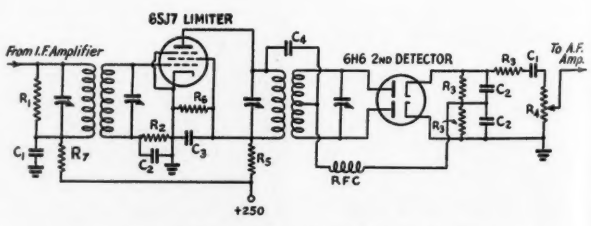
These phase changes are transformed into variations in frequency about the carrier; the Armstrong system begins with essentially phase modulation, but transmits a true frequency-modulated wave by multiplying, up to a limit of 3000 times, the slight phase changes. We have seen that the maximum phase deviation must not exceed 30 degrees. Armstrong has given the example that if the frequency ranged from 30 to 10,000 cps, and 30 degrees were taken as the maximum shift, then the highest frequency would cause a shift of only 0.09 degrees as can be seen by setting up the inverse proportion. Yet the minimum shift of the transmitted wave must be of the order of 45 degrees in order to cause 100% modulation of the wave. Therefore the shift must be multiplied up to the necessary value, the carrier also being multiplied and reaching a final value in the neighborhood of 40 mc, a process which required strict linearity of the circuits involved and a large number of tubes. Both of these factors have been mentioned as disadvantages of the system. After these multiplications the carrier is fed to the usual power stages and radiated from the antenna. The turnstile antenna at W2XMN has a gain of two. At this point it can be seen that since the amplitude of the wave carries no intelligence, it need not be linearly transmitted, as is necessary with amplitude-modulation, and that therefore higher-efficiency class-C amplifiers can be used, instead of class-B.

In the receiver, the frequency-modulated wave must once more be changed to amplitude-modulated wave which will faithfully represent the signal, and then must be passed through a detector circuit before appearing in the loudspeaker. One network accomplishing this consists of a pair of capacitance-inductance circuits with input from the intermediate-frequency amplifier, which in turn receives the output from the limiter, where amplitude variations added by noise were smoothed off the wave. One circuit is non-responsive for the highest frequency, the other for the lowest frequency of the voltage. The carrier frequency passes through the point where the two response vs. frequency curves cross. On one curve, the higher the frequency of the modulated carrier above the central frequency, the greater the response—in other words, the greater the amplitude of the output voltage. The other curve serves the same purpose in transforming the symmetrical halves of the wave from frequency-modulated to amplitude-modulated voltages. The output from each of these circuits is subsequently led through a linear, a periodic amplifier, and a linear rectifier, and finally coupled in adding series to the speaking device by means of transformers. Since translation of the signals at the receiver must be linear, in order to prevent the generation of harmonics it is sometimes advisable to separate the two non-reactance points by more than the band width in order to avoid operation on the non-linear peaks of the response curves.

It is advisable to use high-quality speakers with these sets. Otherwise the gain of the system will be lost in the last step.

In conclusion it may be stated the frequency-modulation accomplishes the elimination of noise fully according to claims, but that it involves such a tremendous change in the communications industry that it cannot replace amplitude-modulation in any short time. A series of test narrow-band and wide-band frequency - modulation, and amplitude - modulation broadcasts on high frequencies have just been begun by the National Broadcasting Company from the Empire State Building in New York City. The comparison thus made possible may be of great importance in determining whether frequency-modulation will replace amplitude-modulation at all.

Assist. Prof. McLean of the communications department has kindly assisted in the preparation of this article.



Circuit of the Receiver Shown Above.
—Courtesy of QST

Prominent Engineers

JOSEPH E. GRIESEDICK, A.E. '40

Spring is almost here. With it not only comes warmer weather but also the return of the baseball season. Then Joseph E. Griesedick, as manager of freshman baseball, will supervise the squad and arrange for its trips. However, his interest in sports is not restricted to managing the baseball team, for he has played softball, football, and soccer on his house team. In addition Joe made the golf squad in his freshman year. He believes that the managerial competitions offer very valuable experience because they enable you to meet people and make new friends.

A member of Tau Beta Pi, Quill & Dagger, and Red Key, Joe is also president of Kappa Tau Chi. His miscellaneous activities include ASME, Frosh Advisory Committee, Pistol team, Golf Club and Newman Club. Despite these numerous activities he has managed to keep in the first quarter of his class.

Discharging his duties as rushing chairman of his fraternity, Delta Tau Delta, during his junior year, required much of Joe's time. His responsibilities were extended when, during his junior year, he was elected house president. Last summer he represented his chapter at the national fraternity convention.

Joe likes to take motion pictures both of the Cornell campus and of university life; he also "shot" a number of reels while travelling last summer throughout the West.

During the summer following his freshman year he was a counsellor at a boys' camp in Colorado. The next summer he did laboratory and manual work in the Falstaff Brewing Corporation. Even though his father is an officer in this corporation, Joe plans to work up from the bottom. In this way he expects to get a practical knowledge of the feelings of labor and an idea of their conditions which will better enable him to serve as an executive in later years.

Though many persons nowadays prophesy the future by any method from crystal globes and decks of cards to analyses of handwriting and astrological phenomena, it requires no such conjecture to tell here and now that red-haired Joe has the personality and ability that will qualify him well for the executive position he is sure to attain.

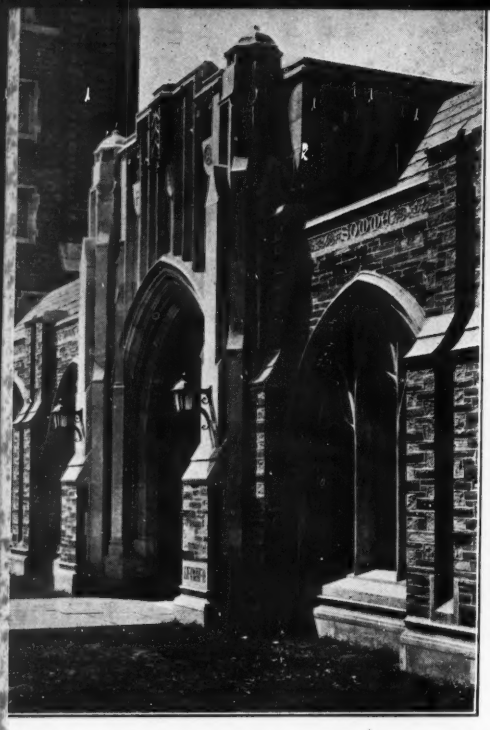
WILLIAM ARTHUR GAY, C.E. '40

Although he had an older brother studying electrical engineering at Cornell, Bill Gay came to Ithaca mainly because he had heard of the excellent civil engineering course given here. Bill, whose home is in Montclair, New Jersey, is an excellent scholar and an all around fellow. At school he is not specializing in any particular branch of civil engineering as he believes that the broader scope of the general course he is taking will give him wider knowledge with considerable opportunity for specialization later. At present he is even taking a number of courses in the Colleges of Arts and Sciences and Agriculture. After graduation, however, Bill expects to enter general construction work.

In a few months Bill will be seen swinging a mean racket on the courts of Ithaca, as tennis is Bill's favorite pastime. When he is not playing tennis, running with the track team helps keep him in shape. Shooting is another of his hobbies, for he is a member of the Cornell Pistol Team.

Last summer Bill attended the United States Army R.O.T.C. Field Artillery Camp. As a Cadet Colonel in Field Artillery he spends much of his time in Barton Hall. The summer of his sophomore year was spent in surveying camp, which, according to Bill, served as an excellent means of getting to know well all the fellows in his own class and also as a successful method of uniting the class. His freshman summer was occupied by instructing a boy's group from the Montclair Y.M.C.A.

As a Cadet Officer Bill is a member of the Officer's Club and Scabbard and Blade. He has been honored by membership in Chi Epsilon, Phi Kappa Phi, and Tau Beta Pi, and he is a member of the American Society of Civil Engineers, the A.S.T.M., the Civil Engineering Council, and the Civil Engineering Honor Committee. He has been very active in helping to organize the Civil Engineering Council which was just started this year for the purpose of uniting the students in the Civil Engineering School.



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EDITORIAL

Forty Finally Fades

It hardly seems possible, but once again the time has come for the old board to retire and make way for the new. It seems only fitting for the class of '40 to say a few sentimental words in this, its last issue.

Perhaps we should say something of our confidence in those who are about to move into our places. We are sure that they will do a better job than we did, which is only as it should be. The next few issues, however, will tell the tale far better than anything we can say.

Perhaps we should say how much we enjoyed the job of seeing to it that the ENGINEER did come out throughout the last year, but again our words would mean little. The very fact that we all did our jobs voluntarily is evidence enough that we enjoyed them.

Then again, we might say a few words to all of those outside the board who made the magazine possible. Without the support of our subscribers and advertisers, the faculty of the College of Engineering, the Cornell Society of Engineers, and our numerous contributors, our existence would indeed have been precarious. The very fact that we are moving forward proves that the essential support is present.

Just in passing, we might observe that it is a good thing that the Juniors are taking over, because the Seniors seem to be putting most of their thoughts and efforts on the problem of earning their daily bread.

To those who succeed us, then, about all that remains to be said is that organization cannot be stable. Either it moves forward, or it moves backward. We hope that our outlook has been forward, and that you, in turn, will move one step nearer to the accomplishment of those things which every new board solemnly vows to do, but never quite accomplishes. We hope that you will aim just a bit higher than we did, and that your accomplishments will keep pace with your aim. Just now, we are a bit too busy taking aim on a new target to say much more than good-bye—and good luck!

News of the College

With only weeks till Easter, and but little more to Spring vacation, old Cornell begins the annual renascence. The track men up at Schoellkopf begin to paw the ground and wish for a thaw so they can get their spikes in cinders again. Surveyors long for grassy slopes, now well fertilized, and the warmer days when coeds cease wearing ear muffs and woolen socks. And everyone prays for the sun to make the Sibley steps warm enough to sit on. However, dreams of radiant warmth will probably be rewarded by snow. We can only hope February's blizzard will not be repeated, when Nature scored a moral victory over Wetherlow's Rangers, those stalwart drivers of the snow plows, who did not clear campus walks for two days. Of course they can not be expected to shovel out Mrs. Roosevelt and the quadrangle too.

For seniors, these last months at Cornell will be busy with interviews and preparations for landing a job after they find themselves in the cold, cold world. In line with this activity are the series of non-resident lectures offered by the college and given by outside experts to acquaint embryo engineers with present day problems in industry. February 16, Robert Thurston Kent, editor of the "Mechanical Engineer's Handbook" and general manager of William Sellers Company, Philadelphia, told the seniors "What the General Manager Thinks About." Named after Dr. Robert Thurston, first director of Sibley, Kent has had a rich engineering background, following in his father's footsteps as editor of the "Handbook." February 23, Tell Berna '12, general manager of the National Machine Tool Builder's Association, discussed "Machine-made Jobs," expressing his opinions on how machines create jobs. While at Cornell, Berna was a famous runner; intercollegiate cross-country champ in 1909, and holder of the two-mile record which remained unbroken from 1912 to 1934. Of special interest to mechanical engineers were the moving pictures shown by Otto DeLorenzi '16 ME. The pictures showed combustion of coal in modern boiler furnaces, and operation of modern water cooled stokers. This non-resident series is given in 2 West Sibley every Friday at 12, and we suggest to all in the college who are free at this time that they drop in and absorb some up-to-the-minute tips on modern industry.

Another type of contact with the latest engineering developments is afforded by the new equipment recently acquired by the college. Through the efforts of O. E. Buckley '14 and E. F. Watson '14, of Bell Telephone Laboratories, a complete set of teletypwriter equipment has been installed in the electrical engineering laboratory, the gift of the Bell company. And for the M.E. students, Pratt and Whitney has donated a variable pitch airplane propeller, a cylinder assembly, and other parts suitable for demonstration. These additions were secured through the efforts of J. Carlton Ward Jr. '14, general manager of the company.

Another addition to the long line of text books by Cornell professors comes with the publication of "Vapor Charts" by F. O. Ellenwood and C. O. Mackey, of the heat power department. Already familiar to heat power students, the charts are used in the fields of steam power, refrigeration, and air conditioning.

We notice that February had its usual quota of faculty junkets to meetings and conventions in various parts of the country. Professors Scofield, Urquhart, and O'Rourke of the civil engineering faculty journeyed to Chicago for the American Concrete Institute convention, February 27-29. Professor Scofield went on to Detroit for the spring meetings of the American Society for Testing Materials. Director Malcolm of the civil engineering school did his share of traveling when he attended the meeting of the Engineering Institute of Canada in Toronto, February 7-9.

Johnny Bangs didn't go anywhere, but he got into the national scene in engineering education by his reappointment as chairman of the Committee on Development and Placement of Engineering Graduates. Other members of the Society for Promotion of Engineering Education represent California, Northwestern, Rutgers, Illinois, M. I. T., Georgia Tech, and General Electric Co.

On the campus, the societies in various schools held their regular February meetings, with some very interesting attractions. AIChE, chemical society, heard Dr. D. G. Zink, development director of U. S. Industrial Chemicals Inc., discuss the "Continuous Production of Anhydrous Ethyl Alcohol". Illustrated by diagrams and slides, the lecture was of special interest to upper-classmen. More recently, on February 22, new officers were elected, all from the class of 1941. New president is George Gentes, Bob Pressing took over the secretary's chair, and Ed Wardwell became the new treasurer. It was decided also that regular meeting should be held on the first Wednesday of each

(*Contnued on page* 25)

CORNELL SOCIETY of ENGINEERS

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"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students and to establish a closer relationship between the college and the alumni."

President's Column

Fellow Engineers:

In my three previous columns in the Cornell Engineer, which were devoted to a discussion of the ideals in technical education, I stressed the need for more thorough fundamental training and the dangers of an over-crowded or specialized curriculum. I also pointed out the advantages to the college of selective admission. It is only by such admission restrictions that the desired character of training can be made effective and the prestige of the institution enhanced through the quality of its graduates.

There has been a tendency in recent years for technical schools to over-emphasize the importance of modern and elaborate physical equipment, but in the experience of our engineering alumni and employers, this is not the thing that counts. The consensus of opinion of the Executive Committee of this Society, as expressed by one of its members, is that in relative rating plant counts 5% and quality of instruction 95%. This idea was forcefully expressed by a former Cornell professor, the late C. F. Hirshfeld, who stated that the one essential of a technical college was "a good teacher with a blackboard." Physical equipment is not a substitute for quality and character of instruction. Good physical equipment, especially a good research laboratory, is essential, however, to attract, develop and retain a good teaching staff. For this reason, a well equipped laboratory for graduate research, headed by an able research engineer of national repute, is one of the best means of building up the teaching staff of a college. We need this at Cornell.

Not only is there a danger in over-emphasizing the importance of physical equipment at the expense of good instruction, but there is also a danger in over-emphasizing the technical side of education at the expense of the human aspect of education. The engineer's success depends fully as much on his ability to deal successfully with human problems as it does upon his ability to deal with mechanical problems. Indeed, if a man possesses the former ability without the latter, he may be a failure . . . even as an engineer, while with the latter, even without the former, he will at least succeed as a man.

Many believe that the important subject of human relations can only be taught through environment and example. I must confess that I, too, was once of this opinion. However, this essential element of education should not be left wholly to chance. One has only to read Dale Carnegie's book, "How To Win Friends and Influence People" to realize this. I would recommend this book as required reading by both faculty and students.

We alumni are glad to see that this important phase of education is being appreciated at Cornell. It is being instilled in the course in Administrative Engineering, but it should not be neglected in *any* technical course. A technical college which has on its faculty, a preponderance of "cloistered" professors cannot be a wholly successful college. Too academic an atmosphere is not healthful . . . especially to those students who are most in need of stimulation and guidance in social relations. Too often the excellent student, as well as the college professor, is or tends to become, in parlance of the psychologist, an *introvert* and needs help in overcoming this tendency.

The engineering alumni are glad to feel that Cornell is taking further steps in this direction.

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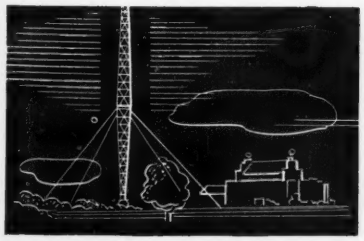

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NEWS OF THE ALUMNI

Herbert S. Austin, C.E. '07, came back to the Cornell campus February 6 to describe for members of the Ithaca Section of the A.S.C.E. and their guests the construction of the pipeline which brings oil from the fields of Iraq across the Arabian Desert to the Mediterranean. He was engineer of design and construction on this $48,000,000 project, which now brings into the world market 30,000,000 barrels of oil a year.

Mr. Austin was selected for the post by the Near East Development Corporation; an American company set up to handle an interest of approximately 25% in a concession by the government of Iraq to develope the oil resources of the country. Engineering was allocated to the Americans and the protection of health and manufacture of a large part of the materials to the British and French. His services were lent by the Standard Oil Company of New Jersey.

The Iraq oil field lies 600 miles east of the Mediterranean across a desert most of which had not been explored. During the World War, Mr. Austin said, it was found impossible to cross the desert with the airplanes then available, and the first crossing by automobile was made as late as 1923.

Mr. Austin arrived on the scene in 1930. First he made a preliminary survey of the route. His automobile caravan was lost on several occasions, and often completely bogged down in the desert clay. The party also had great difficulty in crossing the Tigris, Euphrates, and Jordan rivers, all of which flow through the territory which was to be traversed by the pipeline.

The first step was to string a telegraph line across the desert, partly for the purpose of communication and partly as a guide for parties of workmen. They had to import 32,000 telegraph poles. To supply water for the workmen wells and pumping stations were built. Roads had to be built to handle the trucks and trailers which delivered 117,000 tons of pipe to the site of the line.

The line has 980 miles of twelve inch pipe, 300 miles of ten inch pipe, and nine miles of eight inch pipe. It was necessary to use smaller sizes of pipe to reduce the pressure caused by gravity, for in one place the line dropped from 3500 feet above sea level to 700 feet *below* sea level. When the line finally reached the sea, it was necessary to lay nearly a mile of pipe under water because tankers could not approach any closer to the shore.

Eighty-five Americans directed a construction gang of 15,000 men, mostly natives. Among the Americans were expert welders who welded 200,000 joints.

Political difficulties, Mr. Austin said, were often more troublesome than engineering problems. The pipeline crosses five countries, each of which wanted to make sure that its citizens had a fair share of the wages paid native workers. After the line was finished, strife broke out between the Arabs and Jews, and both sides took delight in shooting holes in the line and setting fire to the oil that leaked out. "These fires were beautiful sights—from an airplane," Mr. Austin said.

Mr. Austin has been with Standard Oil since 1911. Before that he was on the Cornell Civil Engineering faculty. He has had charge of the design and construction of pipelines serving various parts of the country from the Texas and Oklahoma fields. For his work in Iraq Mr. Austin received, among other honors, membership in the French Legion of Honor.

Albert P. Craig, Jr., E.E. '27 has been appointed director of the Westinghouse exhibit at the New York World's Fair. He was assistant director of the company's World's Fair activities in 1939, and he also had charge of all sales of Westinghouse electrical equipment to the Fair and exhibitors. Mr. Craig succeeds E. H. Sniffin, retired, both as Exhibit Director and as member of the Executive Committee of the Air Exhibitors Association.

After graduating from Cornell University, Mr. Craig worked on mining camp surveys in western Canada for a year, and in 1928 he became a graduate student engineer with the Westinghouse Company. He joined the sales office of the company's Industrial Division in New York in 1930, where he specialized in working with architects and engineering consultants, helping them plan the electrical needs of their clients.

"The Westinghouse World's Fair Exhibit will present several new features in 1940," the new director declared. It will be more spacious and provide more comfort for visitors." Displays are being rearranged to prevent crowding and to increase the capacity.

J. O. Osterberg, who received his Ph.D. in civil

(*Continued on page* 26)

Use The Cornell University Placement Bureau

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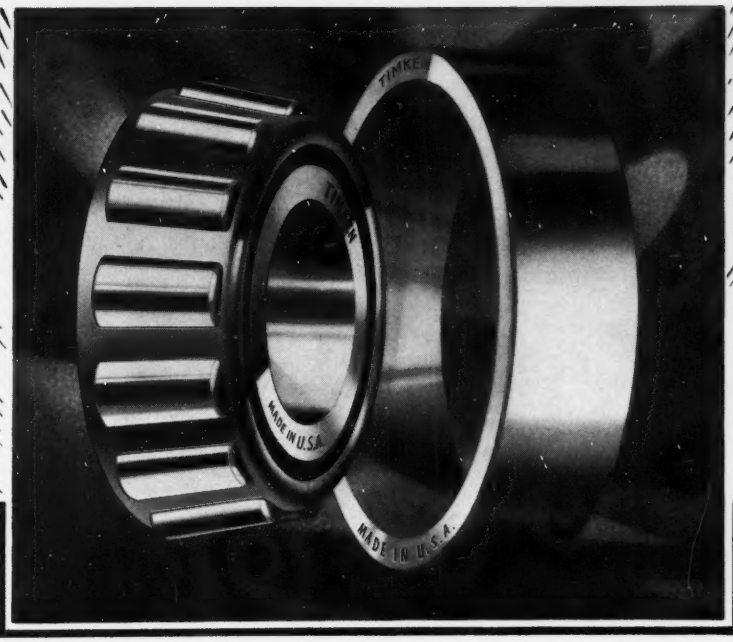
H. H. WILLIAMS, '25, Director



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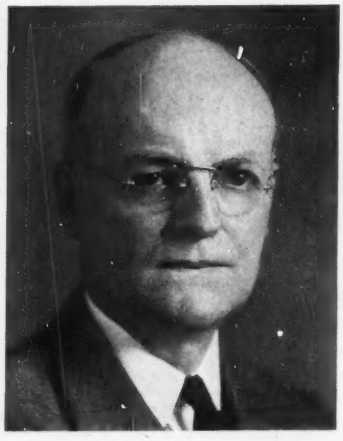

Faculty Personalities

PROFESSOR W. H. HOOK

"My parents named me Warren so that I wouldn't be given a nick name," explained Professor Hook, "And although I often wished for a nick name, at least I wasn't named Clarence or Horace." Assistant Professor Hook is one of the favorite teachers of the Juniors and Seniors who have taken Heat Power.

Professor Hook is a native of Ithaca and graduated from Cornell in 1908. He married a Syracuse coed and admits that they used to have fun kidding each other over their rival schools. In 1910 he started teaching in the Cornell Mech Lab and continued there until 1917. From 1917 to 1920, he worked for Cluett, Peabody & Co., makers of Arrow shirts, where his first job was installing a water softening system. During this war period, the company made case holders for hand grenades for the government in addition to their regular line of the old fashioned stiff collar shirts. In 1920 Professor Hook rejoined the faculty in the Heat Power Department and has been teaching heat power ever since, except for a leave in 1928 when he worked for the Rochester Gas and Electric Company and in 1937 when he worked for the Detroit Edison Company. Since he has worked in Troy and Detroit, Professor Hook maintains that Ithaca weather isn't so bad, for in Troy it rained too often and in Detroit it was hot and sultry.

He laughs when he recalls the time while working in a factory along the old Erie Canal in Rochester he watched an old high stack steam-tug head for a lift railroad bridge which showed no signs of lifting. The skipper merely pulled a rope and the stack dipped and remained down until the skipper pulled the rope again on the other side of the bridge.

During the summer Professor Hook likes to work around his house, building and repairing, or perhaps he may go fishing. He devotes part of his time to the study of genealogy. One of the pleasures he derives from his teachings is recalled when many of the prominent Cornell engineering graduates used to sit in his classes. He believes that his classes run to type in that for each type of student in his present classes, he remembers a similar individual in classes of the past. Professor Hook expresses the belief that the Cornell engineering student is a high type of student and in nearly thirty years of teaching at Cornell has never found a student who might be considered a "dud" or a "rummy." Perhaps it is Professor Hook's belief in the student that accounts for his popularity as a teacher.

PROFESSOR L. C. URQUHART

If you happen to see a nineteen foot "Mower" sailboat on Lake Cayuga, the chances are pretty good that Professor Leonard C. Urquhart is at its helm, for sailing is one of his favorite sports. He is also an ardent contract and tournament bridge "fan." Evidencing this, he and Mrs. Urquhart have been in four national tournaments in the last five years in locations ranging from western Ohio to Washington, D. C.

Having spent two years at Western Reserve in Cleveland, he transferred to Cornell and was awarded his civil engineering degree here in 1909. After graduation, he spent two years designing bridges for the Nickel Plate Railroad. Then, in September 1911, Professor Urquhart came to Cornell to teach civil engineering. He specialized in structural engineering and succeeded Professor H. S. Jacoby as head of that department in 1922.

He also acts as a consulting engineer, being responsible for the structural design of the local court house, the Grange Federation office building, the Biggs Memorial Hospital, and others.

With Professor C. E. O'Rourke, he has written texts on "Reinforced Concrete," "Stresses and Simple Structures," and "Design of Steel Structures." Besides these, Professor Urquhart is editor-in-chief of the "Civil Engineering Handbook," now widely used. During the last ten years, he has advised more graduate students than any member of the engineering faculty. He is a member of Beta Theta Pi, American Society of Civil Engineers, American Concrete Institute, Phi Kappa Phi, and Pyramid.

COLLEGE NEWS

(*Continued from page* 19)

month. In view of the valuable information which is obtainable from AIChE membership, it is surprising that more students in the highly-specialized chemical branch of engineering don't join the society. Open to all chemical engineers from sophomores up, the group will welcome new members.

No less interesting was the talk given by Dr. W. L. Enfield to the AIEE meeting February 16. Field manager of General Electric's lamp development laboratory, Dr. Enfield spoke on new developments in light sources. He exhibited several new lamps, including one about the size of a cigarette, which ran so hot it had to be water cooled.

ASME turned to moving pictures for its meeting on February 20. The film, produced by Johns-Manville Company, traced the history of efforts to make heat useful to man, and showed the part that insulation of various types plays in modern heating.

Also movie-minded were the members of the Cornell Railroad Club as they showed two pictures February 15. Showing the operation of New York, New Haven and Hartford trains and the famous Burlington Zephyrs, the pictures illustrated many features of modern railroading.

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ALUMNI NEWS

(*Continued from page 22*)

engineering from Cornell in January, is the author of an article, "A Survey of the Frost Heaving Problems," which appears in the February issue of CIVIL ENGINEERING.

While at Cornell Osterberg was a McMullen Research Scholar and a member of Chi Epsilon, and did work on pressure cells. He is now continuing this work with the Research Department of the U. S. Engineers at Vicksburg, Miss.

Glenn B. Woodruff, C.E. '10, who is now bridge engineer of the great San Francisco-Oakland Bay Bridge, visited the College of Engineering January 25 to confer with Dean S. C. Hollister and other members of the staff. From 1931 to 1938 Mr. Woodruff was design engineer on the $80,000,000 bridge while it was under construction, and has remained as executive in charge of its operation.

Three graduates of the College of Engineering were honored at a dinner February 19 in Rochester celebrating the 150th anniversary of the United States patent system. The three honored were Willis H. Carrier, M.E. '01, for his work in air conditioning; Charles B. Dalzell, M.E. '02, for simplifications of dairy processes; and James E. Gleason, M.E. '90, for inventions of machines to make new types of gears.

Each of the Cornellians received an engrossed scroll. Dr. Karl T. Compton of M. I. T. was the principle speaker at the dinner which was held in the Chamber of Commerce.

Professor A. G. Christie '09, of Johns Hopkins University, past president of the American Society of Mechanical Engineers, reviews the Cornell University Press's centennial edition of Robert H. Thurston's "History of the Growth of the Steam Engine" in the February issue of "Mechanical Engineering." He recalls that, "Cornell University celebrated in October, 1939, the one hundredth anniversary of the birth of Dr. Robert H. Thurston (1839-1903), for many years the director of Sibley College and one of the outstanding engineers of his day. He was instrumental in organizing The American Society of Mechanical Engineers and served as its first president.

"Dr. Thurston contributed many learned papers on technical subjects to the various societies and wrote an astounding number of books on engineering. A survey of the titles of these books leaves one impressed at the breadth of knowledge of this author and at his versatility. No more fitting memorial to this great engineer and educator at this centennial could have been chosen by the Cornell executives than the republication of one of these works.

"Their choice of, 'A History of the Growth of the Steam Engine' was a doubly fortunate one. In the first place, it has been regarded by many as Dr. Thurston's best work but one which unfortunately is now seldom available in book stores. A more important consideration is its lasting educational value. The crowded curricula of our colleges leave practically no time for the study of the development of steam machinery nor is this subject discussed in many of the modern texts devoted to steam machinery. One who reads Dr. Thurston's book learns of the slow development of the steam engine based upon the meager scientific knowledge then available, and gains an increasing admiration for those pioneers in development who persisted in their work in the face of tremendous difficulties. This broadening of our knowledge of the historical development of the art has a real cultural value."

A. J. Blackwood, M.E. '24, is the author, in collaboration with G. H. Cloud, of an article on the "Characteristics of Diesel Fuels Influencing Power and Economy," which appears in the February issue of the Society of Automotive Engineers Journal.

After receiving his Mechanical Engineering degree, Blackwood spent three years on the engineering faculty at Cornell, instructing in the experimental testing laboratories. He then joined the research staff of Mack Trucks, and had part in the development of their first six-cylinder truck and bus engine.

A job with the Standard Oil Development Company followed his association with the Mack Truck Company, and at present he is in charge of the engine laboratories and the testing and development of automotive, diesel, and aviation fuel.

William H. Hill, M.E. '22, visited Dean Hollister, Professor A. C. Davis, and other members of the engineering faculty on February 17. He is now with the Baldwin Hill Company of Trenton, New Jersey. For some time after graduation he was with the Ingersoll-Rand Company. His home is in Pennington, New Jersey.

Harold M. Sawyer, M.E. '11, who is now vice-president of the American Gas and Electric Company, has been nominated for membership in the Newcomen Society, a group of distinguished engineers in Great Britain and the United States.

Immediately after graduation Mr. Sawyer entered the electrical utility industry at Scranton, and became identified with his present company. He is a member of the Edison Electric Institute and president of the Edison Illuminating Companies.

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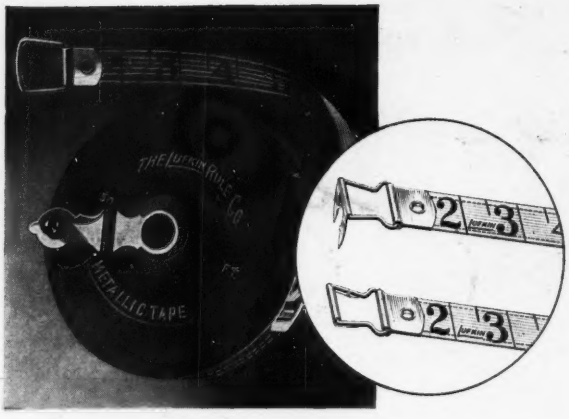

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Frosh: "Ginger Ale."
Waiter: "Pale?"
Frosh: "No—just a bottle."

* * *

Doctor: "Ask the accident victim what his name is, so we can notify his family."
Nurse (a few minutes later): "He says never mind; his family knows his name, sir."

—Pennsylvania Triangle

* * *

"Hello! Is this the Smight apartment? . . . Well I'm McTavish in the apartment below you . . . Listen, it's three in the morning now, and your party has kept me awake all night . . . I don't mind the pounding and shrieking and music and stamping and singing and banging that's been going on over my head, but for gawd's sake put some more sugar in that Tom Collins that's dripping through the ceiling!"

—Penn Punch Bowl

* * *

A baseball game being played in Old Man Jones' pasture broke up in the seventh inning in an uproar when Joe slid into what he thought was third base.

* * *

The Scandanavian had just arrived in California, delighted at the way his new car had withstood the trials and tribulations of the trip.

"How were the roads, Hans?"

"Vell, dis guy Lincoln vas huh great engineer, but dat Frenchman, DeTour, he vas no road builder at all."

—Rose Technic

* * *

Willie: "Did Edison make the first talking machine, pa?"

Pa: "No, son, God made the first one, but Edison made the first one that could be shut off."

—Washington State Engineer

* * *

The Judge: "So your name's Joshua, eh? You're not the Joshua that made the sun stand still, are you?"

Culprit: "Lor', no, Judge. Ah'm de Joshua dat made de moonshine."

* * *

"Why is a corset like an ash cart?"

"Because it goes around gathering up waist."

—Washington State Engineer

* * *

R.O.T.C. Junior Officer (drilling frosh): "Attention! Stand erect! Let your legs hang down!"

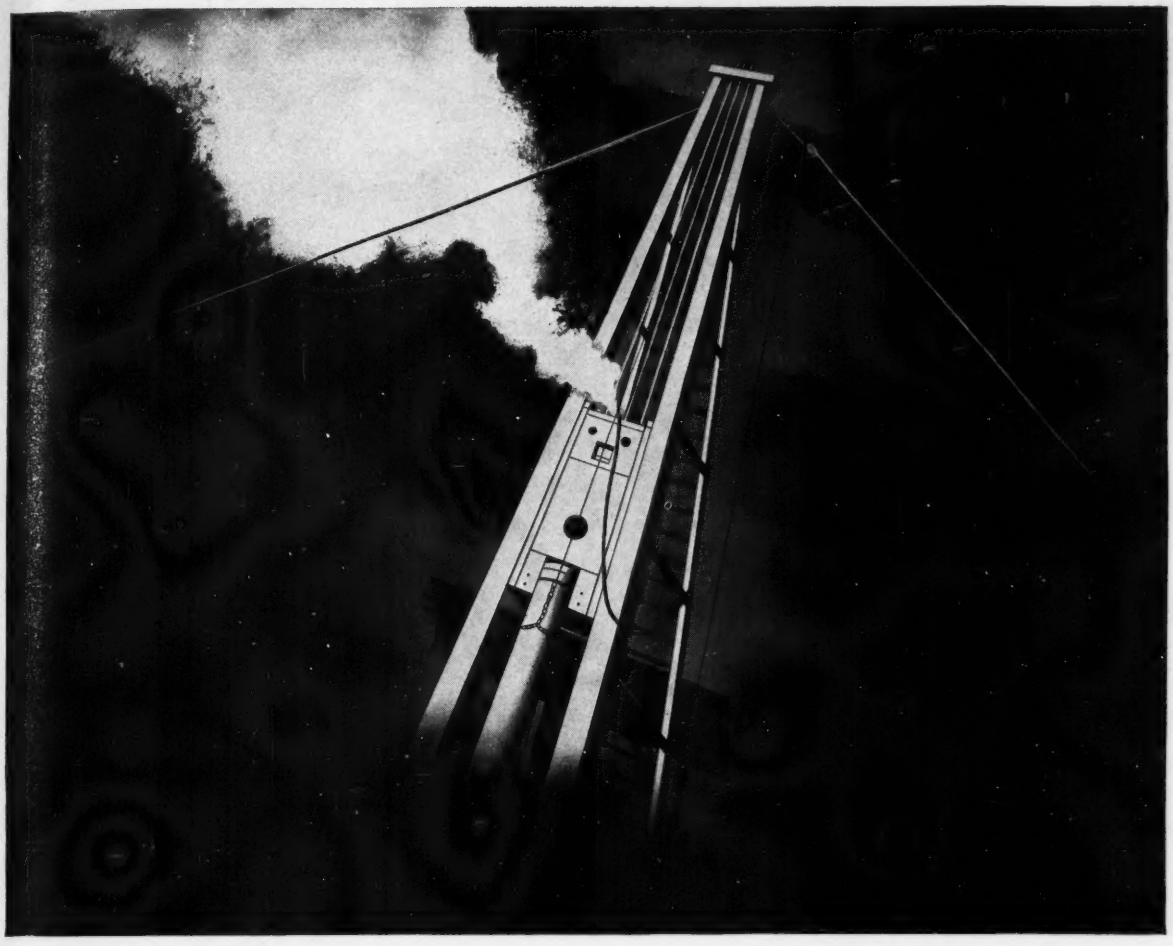
* * *

A policeman making his rounds in the early morning found an inebriated individual standing in a horse trough and waving his handkerchief over his head.

"Hey, what are you doing there?" asked the cop.

"Save the women and children first—I can swim," the drunk answered.

—Washington State Engineer



PILE DRIVERS CAN'T CALL "TIME OUT"

When a pile driver goes to work time is generally the essence of the contract, with penalties for non-fulfillment an ever-present threat. Hence the ability to give continuous service under difficult conditions and with a minimum of attention is an essential requirement. That, in turn, depends largely on the choice, for each part, of the material best adapted to the job.

One manufacturer, whose pile drivers have made an enviable record for trouble-free performance, guards dependability by making the ram piston — a vital part — of Nickel-Chromium-Molybdenum Steel. This steel develops to a high degree the particular combination of toughness, strength and hardness, in the heavy sections used, which is necessary to withstand the rigors of the service.

Our interesting booklet, "Molybdenum in Steel", which contains a great deal of practical, helpful data, will be gladly sent free on request to technical students and others interested in improved materials for modern needs.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

Climax Mo-lyb-den-um Company
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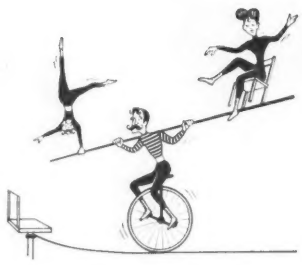
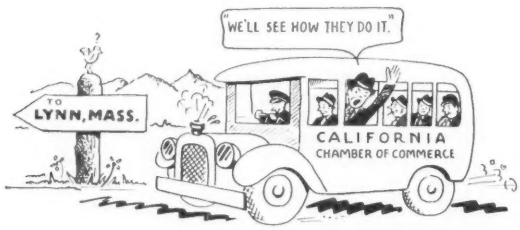


SIMPLIFIED BALANCING

HOW about balancing a 50-ton generator rotor turning at 3600 rpm? No, not on the end of your chin or anything like that, but balancing it until its vibration is less than three ten-thousandths of an inch—or one-tenth the diameter of a human hair! Not so easy, you say? Well, a little while ago you would have been right, for the balancing of a large rotating machine was a long-drawn-out procedure, perhaps requiring the removal of the rotor from the machine.

But today there is a G-E portable instrument that does the job simply, quickly, and under actual operating conditions. A 20,000-kva synchronous condenser, for example, can sometimes be balanced in as few as three runs—a far cry from the 100 to 170 trials which were frequently necessary before.



WEATHER MAKERS

CALIFORNIA'S weather has always been a source of pride to the natives, but when it comes to actually making the weather conditions you want, the G-E engineers at the West Lynn Works are in a class by themselves.

These engineers produce temperatures ranging from 40 below zero F to 160 above and a humidity of 100 per cent if so desired. But they really aren't trying to compete with California. The excuse for all this weather-making is the testing of watthour meters. For G-E engineers want to be sure the meters are capable of accurately recording the amount of electric energy consumed under varying conditions of temperature and humidity.

To insure this, the meters are tested at temperatures more extreme than they would ever normally encounter and in atmospheres saturated with moisture. Such tests, made by young college-trained engineers, assure reliability.

THIRD GENERATION

GENERAL Electric became a proud grandfather this year, when Charles E. Wilson became president and Philip D. Reed chairman of the board of directors—the third generation of G-E leaders. They will carry on as "captain" and "navigator" of General Electric in place of Gerard Swope and Owen D. Young, who held these positions from 1922 until their retirement at the first of this year.

Mr. Young and Mr. Swope leave behind them a brilliant record of achievement. Under their leadership General Electric fostered a great new branch of the electrical industry—the manufacture of appliances which eliminate the drudgery of housework and create comforts and conveniences for the home.

Through their efforts General Electric's many employee plans were achieved—old-age pensions and group life insurance, a wage-adjustment plan to meet increases in the cost of living, vacations with pay, an employee savings plan and many others—ample evidence that these executives were many years ahead of their time in vision and consideration for the welfare of their employees.

GENERAL ELECTRIC

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